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DRAWINGS ATTACHED

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(54) IMPROVEMENTS IN OR RELATING TO MEANS FOR CONTROLLING THE TRAVEL OF A TOOL OR THE LIKE ALONG A PREDETERMINED PATH

(71) We, A.I. WELDERS LIMITED, a British Company, of 98 Academy Street, Inverness, Scotland, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described

This invention relates to means for controlling the travel of a tool or the like along a predetermined path. The term "tool or the like" is intended to mean a cutting tool, a welding torch, a paint applicator or any other component employed in an industrial process to cut, join together or apply paint or like material to a workpiece or assembly of workpieces, which component is required to travel along a predetermined path.

It has already been proposed to control the travel of such a tool by first recording on a magnetic tape or like recording medium signals derived from the movement of a member manually guided along the desired path of the tool and playing back the recording to operate motor devices controlling the movement of the tool during the working operation, and it is the object of the present invention to provide means for facilitating accurate recording of the desired tool path.

According to the invention, there are provided means for effecting travel of a tool or the like along a pre-chosen path comprising a tool-carrying head mounted for movement in at least two directions and adapted to support a tool capable of being fixed in a predetermined operative position relative thereto but movable from said position, a probe, and means for mounting said probe, when the tool is moved from said position, so that it occupies the same position relative to the tool-carrying head as does the tool when in its predetermined position, power means for moving said tool-carrying head, means operated by manual effort applied to said probe to control the power means to drive the said tool-carrying head along a path determined by the direction in which said manual effort is applied, means for recording the movements of the said head along said path and means controlled by playback of the recording to control the power means automatically so as to cause the tool, when the probe is removed and the tool is in its predetermined position relative to the tool-carrying head, to follow the same path as was followed by the probe during the recording operation.

The tool may be mounted on the tool-carrying head for retraction from its operative position, or may be removed from the said tool-carrying head.

The mounting means for the probe may comprise a member mounted for small relative movement in all directions relative to the tool-carrying head, and means actuated by such relative movement to control the power means.

The means actuated by the said relative movement may be electric switches controlling electric or electrohydraulic motors.

One embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a front elevation of an electric fusion welding apparatus embodying the invention;

Figure 2 is an end view of the apparatus shown in Figure 1;

Figure 3 is a sectional elevation, on an enlarged scale, of the tool-carrying head of the apparatus shown in Figures 1 and 2; and

Figure 4 is a sectional elevation, on the same scale as Figure 3 of the means for effecting vertical movement, and rotation, of the tool-carrying head.

Referring to Figures 1, 2 and 3 of the drawings, a tool head 10 consisting of an insulated

[*Price 25p*]

bracket is rigidly secured to the lower end of a vertical shaft 11 (Figure 3) co-axial with and depending from an inner tube 12 rotatable in an outer tube 13 mounted in and vertically slidable relative to a third vertical tube 14 carried by a horizontal bar 15 slidable in the direction of its axis in a carrier housing 16 itself movable along a second horizontal bar 17 positioned at right angles to the bar 15 and fixed at its ends to pillars 18 forming components of a fixed frame of the apparatus. The tool head is thus movable along three mutually perpendicular axes, and is rotatable about one of the said axes. The vertical shaft 11 is rigid with the inner tube 12 which, as shown in Figure 4 of the drawings, carries, at its upper end, a bush 19 in which is mounted a key 21 engaging in a longitudinal groove in a rod 22 depending into the tube 12 from the top of the tube 14, the rod 22 being rotatable by means of an electric motor 23 carried at the top of the tube 14.

A screw-threaded shaft 24, mounted in the tube 14 alongside the outer tube 13, as shown in Figure 4, has mounted on it a nut 25 to which is fixed an arm 26 including a ring portion surrounding the tube 13 and engaging the underside of a collar 27 thereon, the shaft 24 being rotatable by a second electric motor 28 mounted on the bar 15 through a shaft 29 extending along the bar and bevel gearing 31 coupling together the shafts 24 and 29.

The bar 15 is movable in the direction of its axis by a third electric motor 32 mounted on the end of said bar and driving a screw-threaded shaft (not shown), engaging a nut fixed in the carrier housing 16, and the housing 16 is movable along the bar 17 by a fourth electric motor 33 carried at one end of the bar 17 and driving a screw-threaded shaft (not shown) extending along the said bar 17, that screw-threaded shaft having mounted on it a nut which is held in a fixed position in the carrier housing 16.

The second, third and fourth electric motors are controllable, as will be hereinafter described, to provide power-assisted movement of the tool head 10 in response to manual effort applied to the said tool head to move it in any direction, and separate control means are provided for the first electric motor 23, to enable the tool head to be rotated about the axis of the shaft 11. The movements of the tool head 10 when so manually directed and when so rotated are arranged, in known manner, to produce signals which are recorded on a magnetic tape or like recording medium, and further control means are provided for the electric motors, which are operated by playing back of the said record, to cause the tool head to repeat the movements which were effected by manual control.

The signal producing and recording means, and the further control means responsive to playback of the recording are of known form and constitute no part of the present invention, so it is deemed unnecessary to provide any further description thereof in this specification.

Referring now to Figure 3 of the drawings, a sleeve 34, surrounding the lower end of the vertical shaft 11, is capable of limited vertical movement relative to the said shaft and also of slight lateral movement relative to the said shaft in all directions. The tool head bracket constitutes a guide in which is slidably mounted a welding torch 35, the sliding movement of the welding torch 35 enabling it to be moved, in a direction oblique to the axis of the shaft 11, from a retracted position in which it is shown in Figure 3, to an operative position in which its tip projects a greater distance from the bracket. Rack and pinion mechanism 36 is provided to move the torch in the bracket.

The sleeve 34, which is apertured at 37 to enable the tool head 10 to pass through it, has fixed in its lower end a mounting block 38 for a probe 39 which can, as shown in Figure 3, be mounted on the said block when the welding torch 35 is retracted. The probe 39, when so mounted, is in such a position that its tip occupies a position, relative to the tool head 11, identical with that occupied by the tip of the welding torch when the latter is in its operative position. The probe 39 is preferably formed with a tapered tip and with a cavity 41 at its rear end to receive the tip of the welding torch, as shown, thus reducing the degree of retraction of the welding torch which is necessary to enable the probe to be fitted.

By sleeve 34 extends upwardly into a casing 42 fixed to the lower end of the outer tube 13, the said casing 42 having, at its lower end, a rounded internal rib 43 which engages the outer surface of the sleeve 34 and provides a fulcrum about which the said sleeve rocks when its lower end is moved laterally in any direction. Balls 44, mounted in radial recesses in the shaft 11, and urged outwardly against the sleeve 34 by springs 45, locate it normally in a true coaxial position relative to the shaft, there being conveniently three such balls in recesses spaced 120° apart.

The casing 42 comprises a stepped tubular component 46 secured at its larger, upper end to a flange on the outer tube 13 and carrying the rib 43 at its lower, smaller end, and a second tubular component 47 which, with the step portion 48 of the component 46, defines an annular chamber around the lower, smaller end of the component 46. A flange 49 on the upper end of the sleeve 34 lies above, and in spaced relation to, the step portion 48, and a further flange 51, fixed in the larger end portion of the casing component 46, lies above, and in spaced relation to, the flange 49.

Three pairs of spring loaded plungers, the

plungers of each pair being co-axial and the pairs being spaced at 120° intervals around the axis of the vertical shaft 11, each comprise a plunger 52 mounted in a guide 53 in the step portion 48 and a plunger 54 mounted in a guide 55 in the flange 51, the said plungers serving to locate the sleeve in a vertical sense, and a pair of electric switches 56 and 57, mounted respectively in the flange 51 and in the step portion 48, are closable by plungers 58 and 59 respectively engaged by the flange 49 when the sleeve 34 is moved up or down respectively in relation to the vertical shaft 13.

In the lower, smaller end portion of the tubular component 46 there are mounted, on each of two diameters of the component at right angles one to the other two pairs of electric switches, the switches forming one pair being shown at 61 in Figure 3, and one of the switches of the other pair being indicated in dotted lines at 62. The diameters of the component 46 on which the pairs of switches are mounted are respectively parallel to the bars 15 and 17. The switches 61 and 62 are operated by plungers 63 projecting through the component 46 into engagement with the sleeve 34.

The switches 56 and 57 are connected in a control circuit for the second electric motor 28, the switches 61 are connected in a control circuit of the third electric motor 32, and the switches 62 are connected in a control circuit for the fourth electric motor 33. The control circuits are of known type, and are not shown in the drawings, the arrangement being such that closing of one switch of each pair causes the appropriate motor to run in one direction and the closing of the other switch of the pair causes the motor to run in the opposite direction.

The first electric motor 23 is controlled by a manually operated switch 64 mounted, for example, in a control switch housing 65 which also accommodates a switch 66 for providing a signal which is recorded to show when welding is to take place, and an emergency stop switch 67.

A workpiece on which a welding operation is to be performed is mounted on suitable supporting means, generally indicated at 68, between the pillars 18.

In carrying out a recording operation with apparatus according to the invention, the work is set up in the supporting means, the workpiece shown by way of example in the drawing, being a metal drum 69 of which an end wall is to be seam-welded into one end of a cylindrical wall. The required welding parameters, i.e. wire feed speed, amperage, gas flow and torch welding speed are set on the machine. The probe 39 is then mounted on the sleeve 34, after retraction of the welding torch 35, and is brought to the position at which the welding operation is to be started, with the torch axis lying in a predetermined plane containing the axis of the vertical shaft 13, the angular position of the said plane being regarded as a zero position. The first electric motor 23 is set to rotate the shaft 13 and the tool head 10 to a desired starting position, and the recording mechanism and current supply to the motors 28, 32 and 33 is switched on. The sleeve 34 is then grasped by the operator and manipulated to cause the probe to follow the desired welding path, the switch 66 being closed during those parts of the probe travel when welding will be required to take place, and being allowed to remain open during idle travel.

A visual or audible signal is produced when the switch 66 is closed, as well as the signal to the recording medium, but no such signal is provided when the switch 66 is open, although recording of the whole movement of the probe takes place.

If the angle of rotation of the tool head 10 is required to be changed, the probe is stopped, the position is marked, the probe withdrawn, the new rotation angle is selected, and the probe is returned to the marked position for continued tracking, the changed angle of rotation being recorded.

After a sufficient record of the required welding path has been made, the tool head is returned to the starting position, the angle of the tool head is set to the zero position, the probe is removed, and the welding torch is moved in the tool head to the operative position. The recording medium is then returned to the starting position, and playback is switched on, causing the welding torch to follow the path previously traversed by the probe to perform the welding operation.

Instead of, or in addition to, the means for rotating the tool head, means may be provided for rotating the workpiece, the rate of rotation being recorded in a similar manner to the rate of rotation of the tool head.

Whilst the invention has been particularly described as applied to a fusion welding apparatus, it will be evident that it can also be applied to cutting apparatus, such as flame cutting apparatus, paint applying apparatus, or any other apparatus employed in an industrial process to cut, join together or apply paint or other coating material to a workpiece or assembly of workpieces.

The welding torch or other tool, instead of being retractably mounted in the tool head, may be detachable therefrom to permit the mounting of the probe in its operative position.

In the embodiment of the invention described, the tool head is mounted for movement in three mutually perpendicular directions so that it can follow a path which varies its direction in three dimensions. For some operations, it may be necessary to provide only for a path of movement which lies in a single plane, in which case the means for moving the

tool head in one direction, and recording movement thereof in that direction, may be omitted.

It will be appreciated that any other suitable motor, such as an electro-hydraulic motor may be employed in place of the electric motors of the preferred embodiment of the invention described above.

WHAT WE CLAIM IS:—

1. Means for effecting travel of a tool or the like along a pre-chosen path comprising a tool-carrying head mounted for movement in at least two directions and adapted to support a tool capable of being fixed in a pre-determined operative position relative thereto but movable from said position, a probe, and means for mounting said probe, when the tool is moved from said position, so that it occupies the same position relative to the tool-carrying head as does the tool when in its predetermined position, power means for moving said tool-carrying head, means operated by manual effort applied to said probe to control the power means to drive the said tool-carrying head along a path determined by the direction in which said manual effort is applied, means for recording the movements of the said head along said path and means controlled by play-back of the recording to control the power means automatically so as to cause the tool, when the probe is removed and the tool is in its predetermined position relative to the tool-carrying head, to follow the same path as was followed by the probe during the recording operation.

2. Means for effecting travel of a tool or the like according to Claim 1, wherein the tool is mounted on the tool-carrying head for retraction from its operative position.

3. Means for effecting travel of a tool or the like according to claim 1, wherein the tool is removable from the tool-carrying head.

4. Means for effecting travel of a tool or the like according to any preceding claim, wherein the mounting means for the probe comprise a member mounted for small relative movement in all directions relative to the tool-carrying head, and means actuated by such relative movement to control the power means.

5. Means for effecting travel of a tool or the like according to Claim 4, wherein the means actuated by the said relative movement are electric switches controlling electric motors or electro-hydraulic motors.

6. Means for effecting travel of a tool or the like according to any preceding claim, wherein the tool-carrying head is mounted on an axially movable shaft supported for such axial movement on a first bar extending perpendicular thereto, the said first bar being movable in the direction of its length in a housing itself movable along a second bar extending in a direction mutually perpendicular to said axially movable shaft and to said first bar.

7. Means for effecting travel of tool or the like according to Claim 6, wherein the axially movable shaft is rotatable.

8. Means for effecting travel of a tool or the like according to Claim 6 or 7 as appendant to Claim 4, wherein the mounting means for the probe comprise a sleeve surrounding the axially movable shaft and both axially movable and angularly movable with respect thereto.

9. Means for effecting travel of a tool or the like along a predetermined path, substantially as described with reference to, and as shown in, the accompanying drawings.

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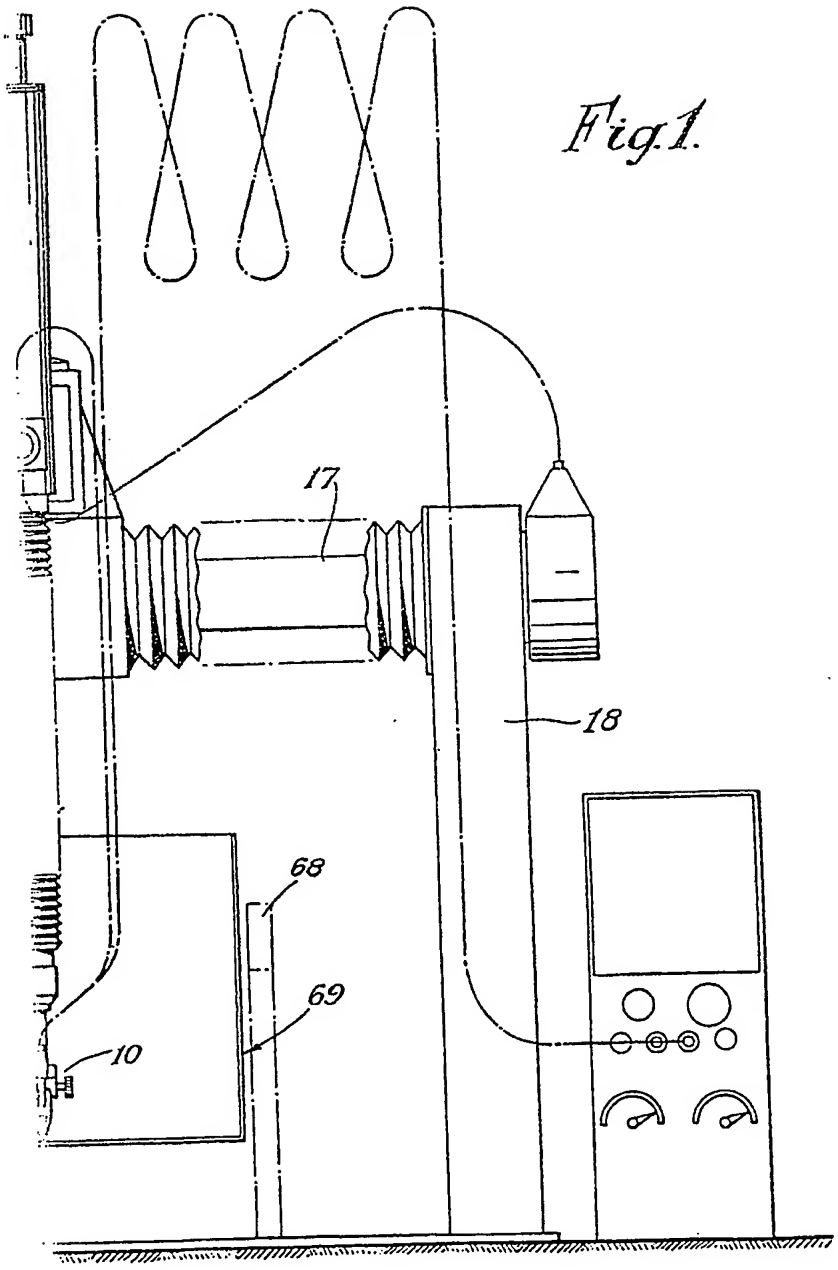
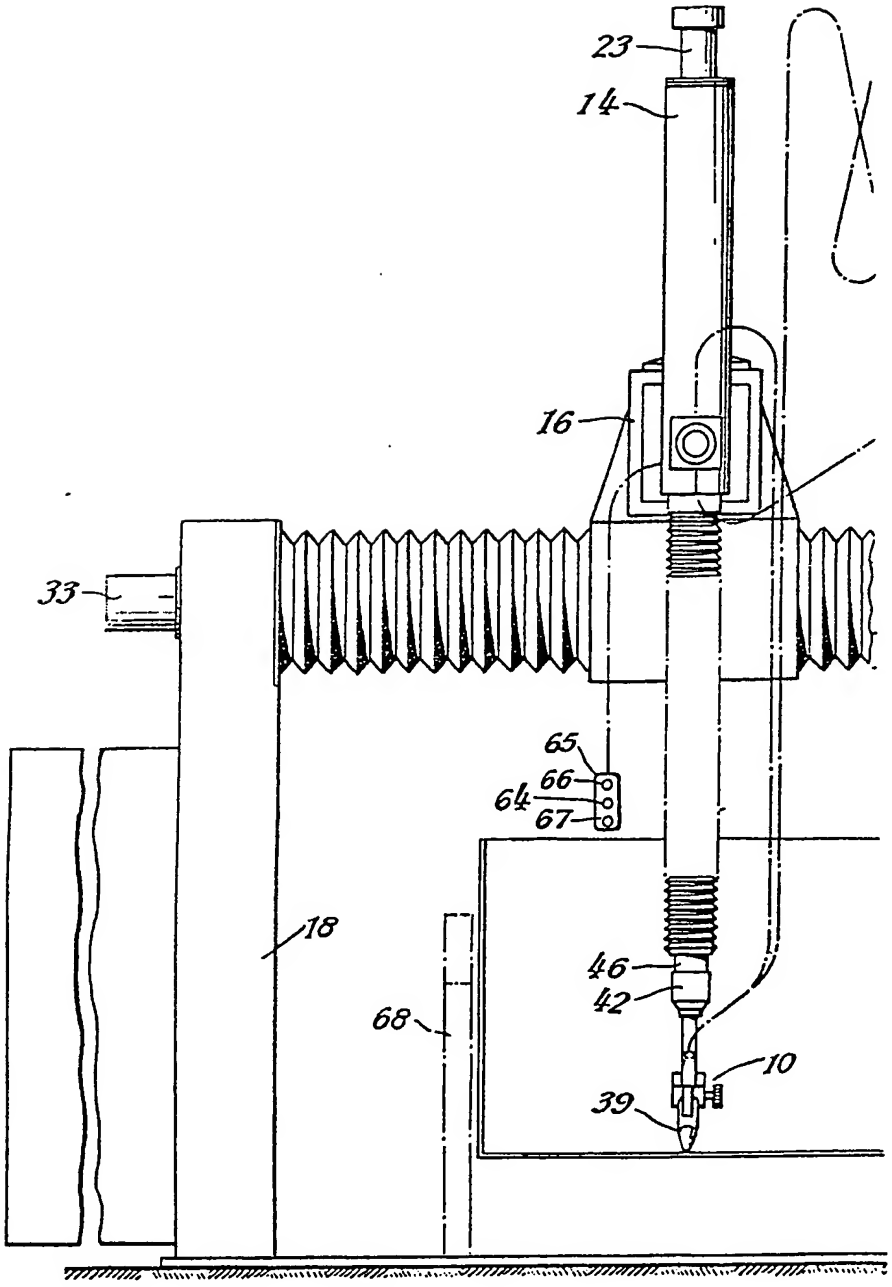
1224180 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig.1.

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Sheet 1

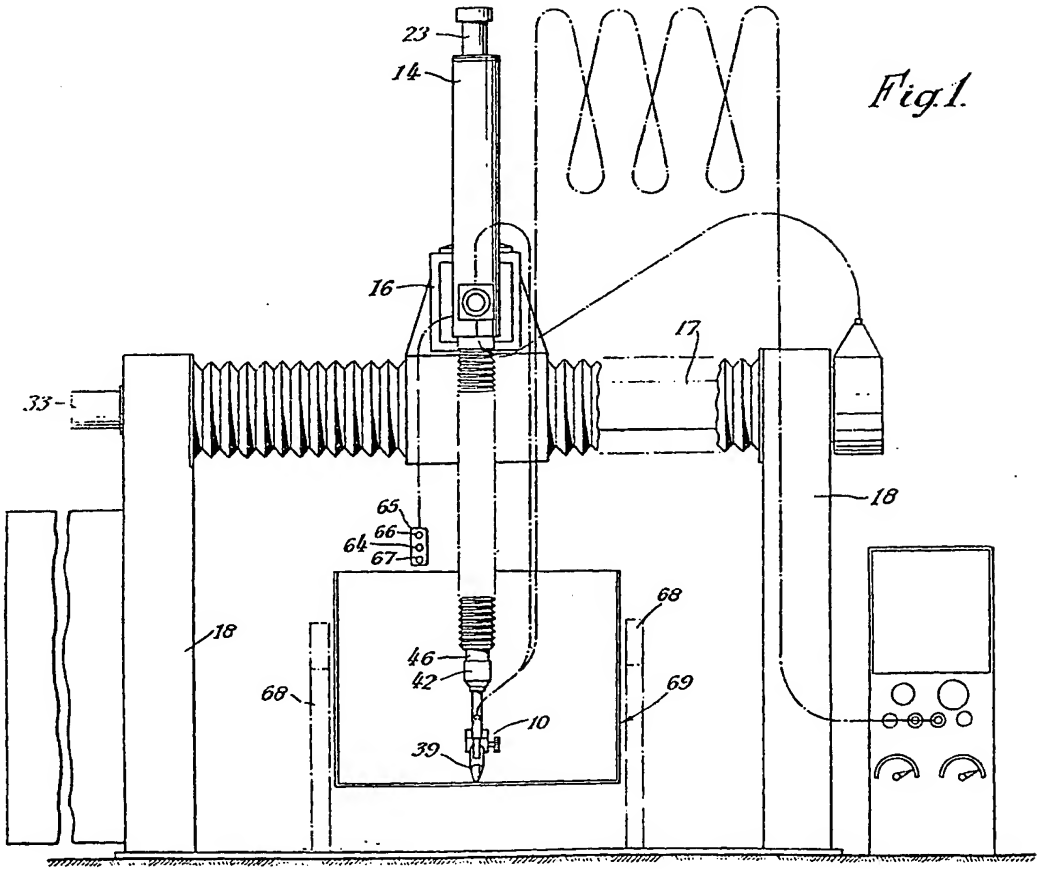

Fig.1.

1224180 COMPLETE SPECIFICATION

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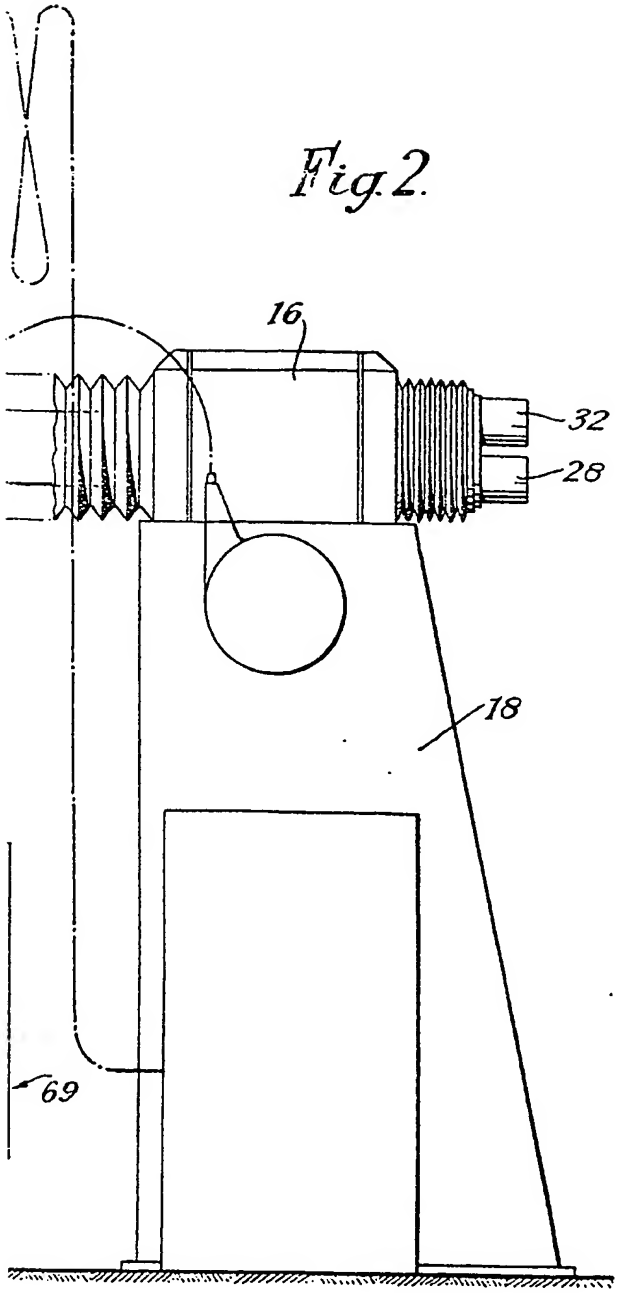
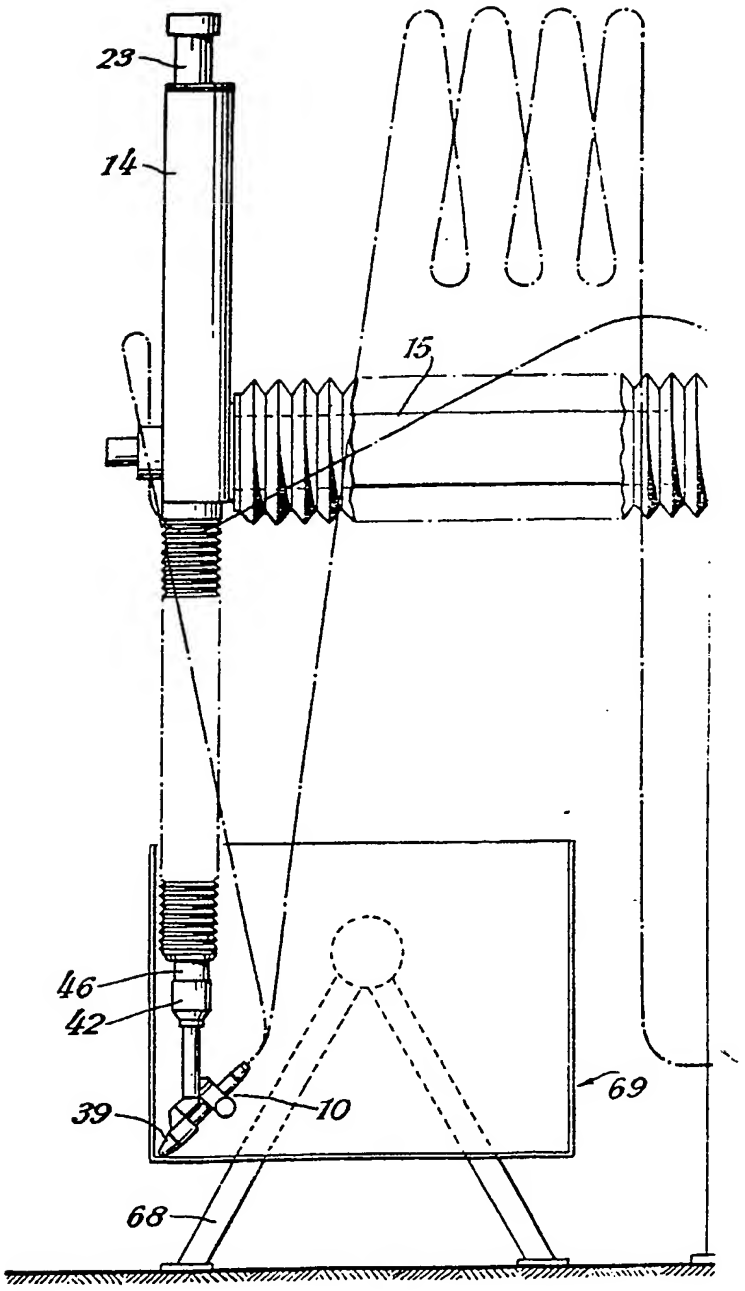
Sheet 2

Fig.2.

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1224180 COMPLETE SPECIFICATION
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Sheet 2

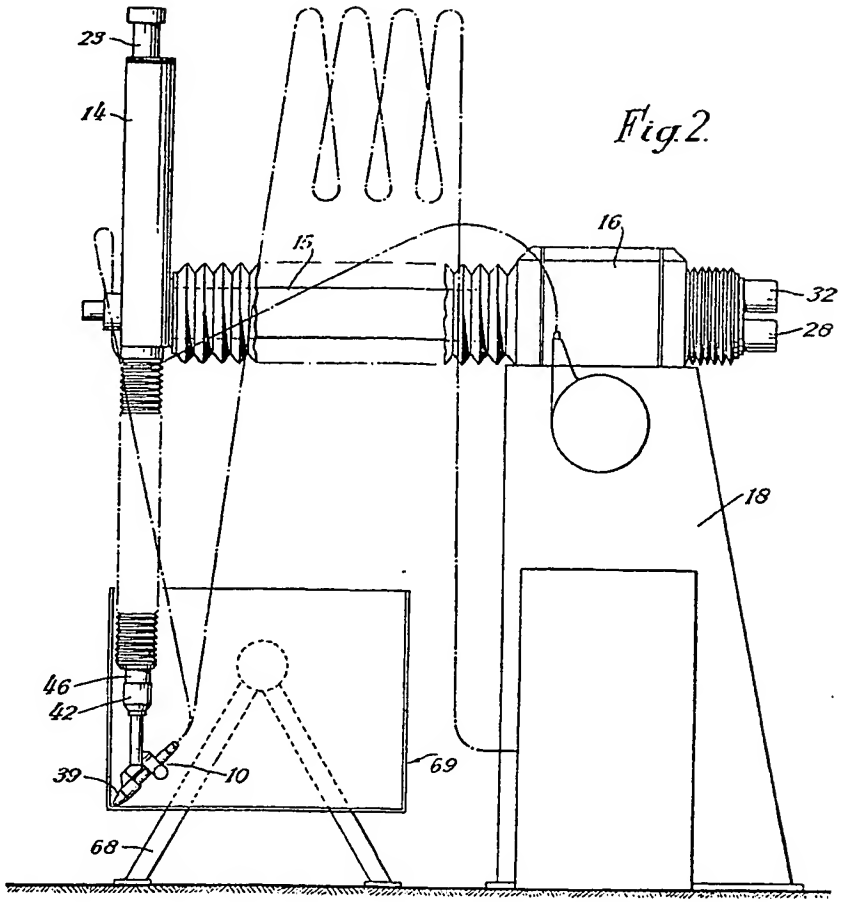

Fig.2.

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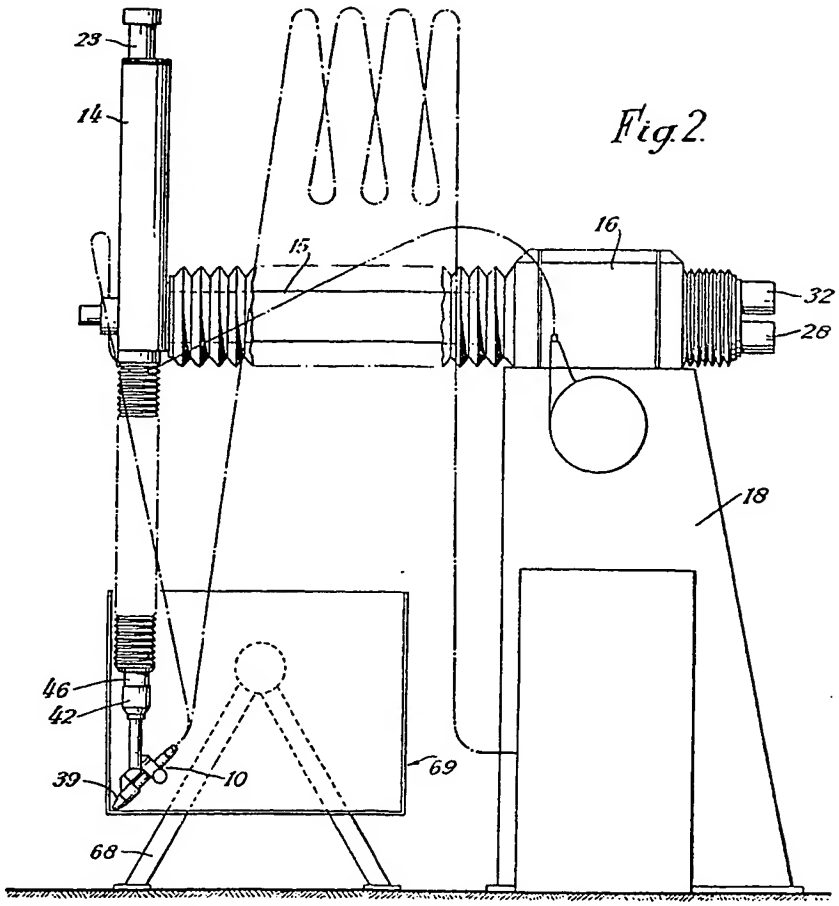

Fig.2.

1224180 COMPLETE SPECIFICATION
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Sheet 3

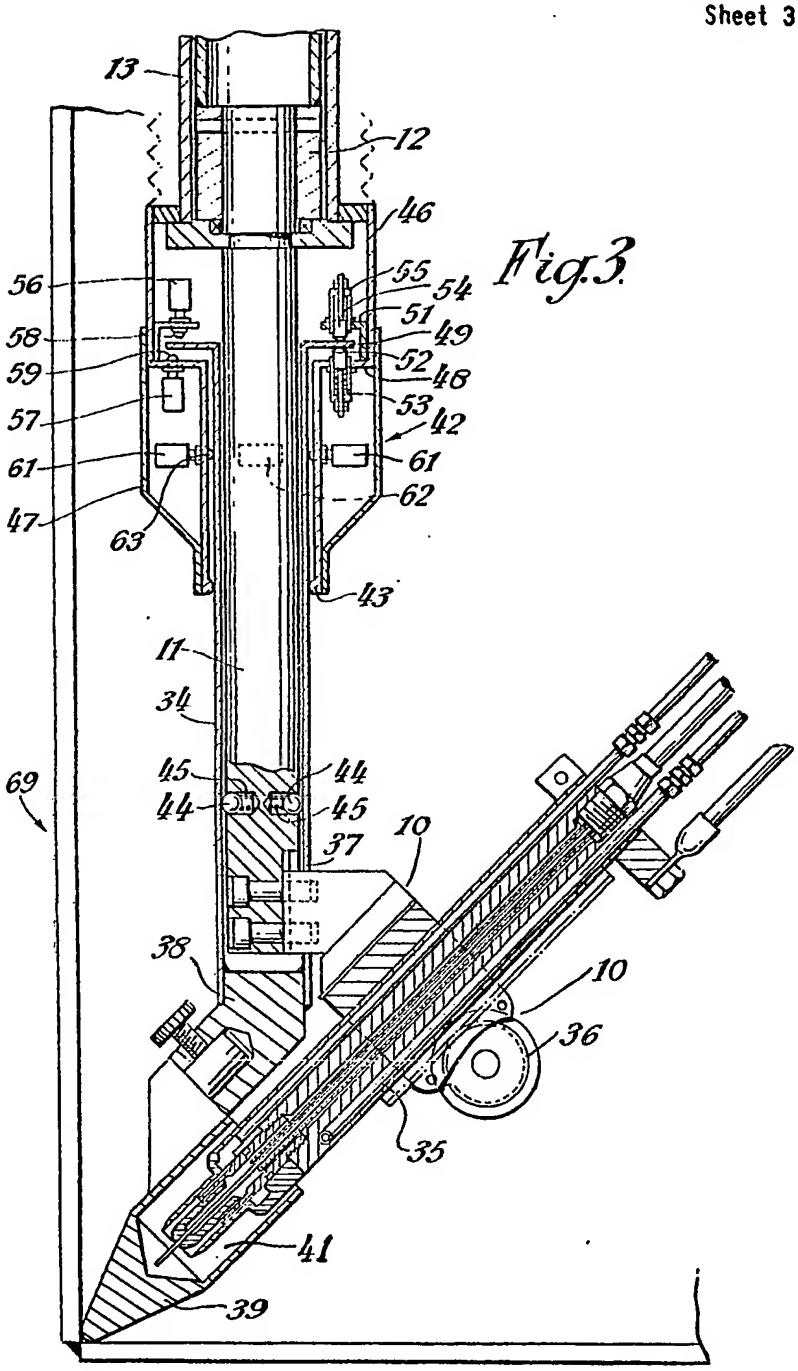

Fig.3.

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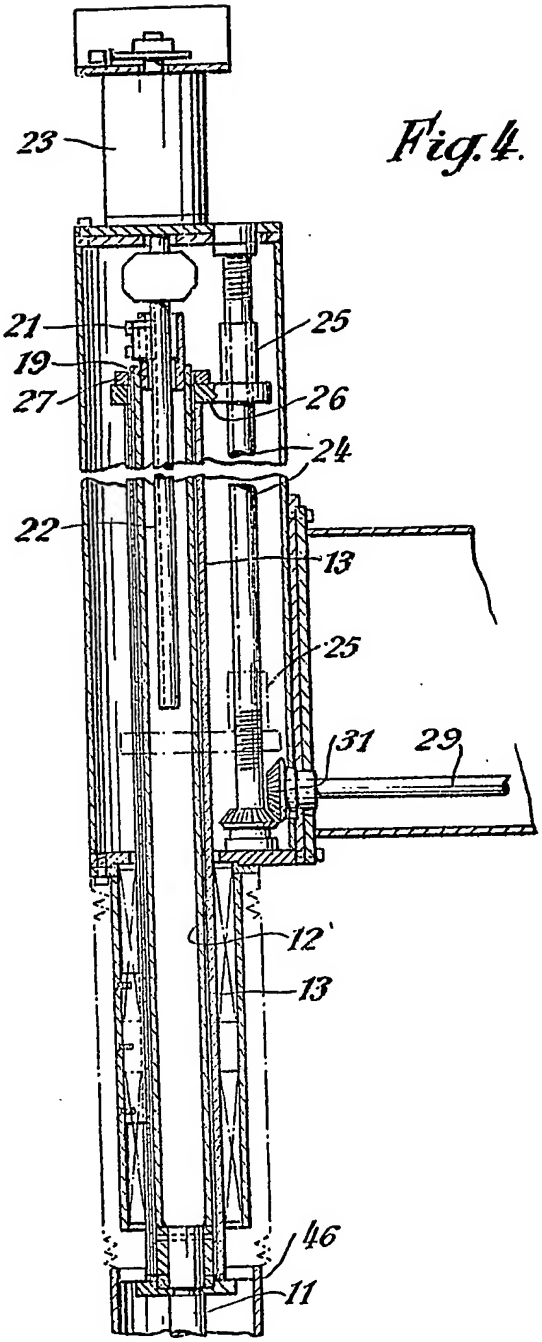
Sheet 4

Fig. 4.



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Abstract

1,224,180. Welding by fusion. A. I. WEL- DERS Ltd. 10 Sept., 1969 [19 Sept., 1968], No. 44536/68. Heading B3R. [Also in Division G3] The travel of a tool is controlled by a record and playback system wherein a probe replaces the tool and is moved manually, with power assistance, along a predetermined path. As shown, Fig. 1, a tool head 10 is rigidly secured to a shaft rotatable by an electric motor 23 within a switching assembly 42, 46 on the end of a tube telescopic into a casing 14. The casing 14 is movable, normal to the plane of the draw- ing, on an arm, not shown, sliding in a housing 16. On the remote end of the arm are mounted an electric motor for effecting normal move- ments and an electric motor driving, through bevel gears and a screw and nut assembly in the casing 14, the telescopic tube. The housing 16 is movable on a shaft 17 between end-supports 18, by an electric motor 33. It is stated that electric motors may be replaced by electro- hydraulic motors. A metal drum 69 to be seam- welded is mounted between pillars 68. A probe 39 is mounted on the tool head 10 after retraction, or removal, of the welding torch and is manually caused to follow the pro- posed weld path with servo-assistance 'of the positioning motors through the switch assembly 42, 46. The rotary alignment motor 23 is operated by a switch 64 in a control housing 65 which also contains a switch 66 for recording a weld operation and an emergency stop switch 67. The movement of the probe is recorded in a known manner and subsequently played back to control position and operation of the welding torch. The tool head 10, Fig. 3, comprises a gas- shielded, consumable wire electrode, arc welding torch 35 retractable by a rack-and-pinion 36 to allow the insertion of a probe 39 in a socket 38. The socket 38 is mounted on a tube 34 which is movable with respect to a shaft 11 carrying the head 10 under restraint from ball-and-spring assemblies 44, 45. Manual movement of the probe causes the tube 34 to (1) slide axially and operate switch 56 or 57 controlling the tele- scoping motor, (2) pivot about flange 53 to operate quadrature switches 61, 62 controlling the normal motor and the motor 33.